NISTTech

Magneto-Optical Trap Ion Source

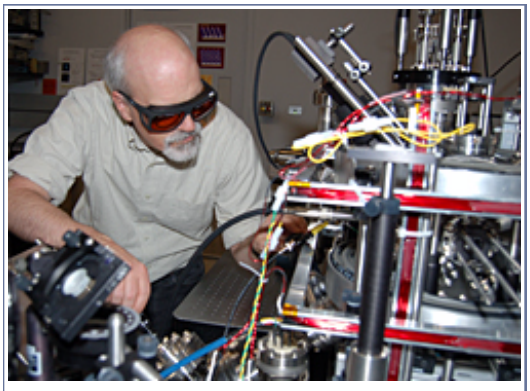
Ion beams no larger than a nanometer sized point

Description

Scientists at NIST have developed a method of focusing a stream of ions into a point as small as one nanometer (one billionth of a meter). It can be used with a wide range of ions for applications in nanotechnology both for carving smaller features on semiconductors and for nondestructive imaging of nanoscale structures with finer resolution than currently possible with electron microscopes.

NIST's team took a new approach to producing a focused ion beam by first generating a small "cloud" of cold neutral atoms using a magneto-optical trap. Such a trap, by combining magnetic fields with laser light, can confine and cool atoms to extremely low temperatures. Another laser is then used to ionize the atoms, and the resulting ions are accelerated through a small hole to create a highly collimated beam that can be focused to an extremely small spot. Researchers have named the groundbreaking device "MOTIS," for "Magneto-Optical Trap Ion Source."

Images



Inventor Jabez McClelland makes adjustments on the new magneto-optical trap ion source

Applications

- **Semiconductor carving**
  The fine beam of ions emitted from the MOTIS device can carve smaller features onto semiconductors while at the same time eliminating the contamination problems associated with gallium ion sources.
- **Nondestructive imaging**

MOTIS enables finer resolution, nondestructive imaging of nanoscale structures than is possible with today's electron microscopes.

- **Precision doping**
  The MOTIS can produce a much larger range of beam currents extending all the way down to single ions on demand.
- **Dual source**
  By changing the polarity of the focusing column, either ions or electrons can be extracted and focused to high resolution.

Advantages

- **Higher resolution and lower beam energy**
  The MOTIS produces an ion beam with a small energy spread, resulting in highly reduced chromatic aberration. This allows a high resolution at low beam energies for reduced sample damage.
- **Lower Emittance**
  The MOTIS has lower emittance at equivalent current output compared with other sources, giving a higher brightness source that allows for finer resolution with higher currents.
- **Can be Realized with Many Different Atomic Species**
  With MOTIS, a much wider range of atomic species can be used to create a focused ion beam--the list is still growing as the field progresses.

Abstract

This invention consists of a new source for creating a focused ion beam. A magneto-optical trap serves as a source of cold atoms that are photo ionized to produce the ion source. Under appropriate conditions, the resulting ion cloud has temperature and spatial characteristics similar to that of the initial neutral atom cloud. An external electric field extracts the ions which can be focused using standard charged-particle optics. The cold temperatures achieved through laser cooling yield an ion beam with excellent characteristics which should allow for a beam resolution of 10 nm or less. The current produced from this source depends on the operating parameters of the MOT and can range from single ions on demand to over 100 pA, a much wider range than is currently possible. In addition, the wide range of elements that can be laser cooled greatly extends the possibilities for ionic species that can be used in FIBs, The net result is a source that has improved characteristics as well as expanded capabilities over current technology.

Inventors

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Citations

1. J.J. McClelland and J.L. Hanssen. Laser Cooling without Repumping: A Magneto-Optical Trap for Erbium Atoms. PRL 96, 143005, 2006.
2. J.L. Hanssen, E.A. Dakin, and J.J. McClelland, M. Jack. Laser-cooled atoms as a focused ion beam source. Phys. Rev. A 74, 063416, 2006.
3. J.L. Hanssen, S.B. Hill, J. Orloff and J.J. McClelland. Magneto-optical trap-based, high brightness ion source for use as a nanoscale probe. Nano Letters 8, 2844, 2008.

Related Items

- Article: Cold Atoms Could Replace Hot Gallium in Focused Ion Beams

References

- U.S. patent # 7,709,807
- Docket: 07-015

Status of Availability

This invention is available for licensing.

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